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THE IMPACT OF ACCOUNTING METHODS
ON COST REDUCTION RATES IN
DEFENSE AEROSPACE WEAPONS SYSTEM PROGRAMS

by

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The Impact of Accounting Methods on Cost Reduction Rates in Defense Aerospace Weapons System Programs

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ABSTRACT

This study investigates the relationship between accounting methods and cost reduction rates exhibited in Department of Defense aerospace weapons system programs. The role of three accounting methods (depreciation, inventory and investment tax credit) in predicting cost reduction rates are studied. Of the three accounting variables, only inventory was consistently associated with program cost reduction rate behavior at a statistically significant level. This finding suggests that in some contexts accounting methods may explain cost reduction slopes. But, the findings were contrary to the expected association between accounting methods and cost reduction, so a full explanation of how accounting methods are related to cost reduction awaits further research.

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I. BACKGROUND: SUMMARY AND REVIEW OF RELATED STUDIES

There have been a set of recent studies investigating aspects of pricing strategies used by government contractors, with emphasis on those strategies used by contractor´s producing aerospace weapons systems. In these studies, contract price refers to the amount the government pays, and contract cost, to the contractor´s cost for an item(s). These studies have explicitly or implicitly argued that; (1) Contractors have incentives to pursue different pricing strategies, depending on financial or economic conditions and that (2) even when contract price is directly tied to contract costs, contractors can pursue a pricing strategy by influencing the measurement of costs. One mechanism that contractors use to influence contract costs is the choice of accounting procedures underlying the measurement of those contract costs.

These studies generally argue that contractors choose between two broad pricing strategies: penetration (low initial price, followed by little subsequent price reduction) or skimming (high initial price, followed by substantial price reduction.) To pursue these alternative strategies, contractors choose accounting methods that result in either "early" or "late" recognition of costs. Early recognition of costs would tend to result in higher costs and prices for

initial units produced and be consistent with a skimming strategy. Later recognition of costs would tend to be consistent with a penetration strategy.

These studies essentially fit learning curves to a series of cost data to measure the degree of price reduction experienced on real world aerospace programs, i.e., to operationalize the concept of pricing strategy.

Two studies, by Moses, and McGrath and Moses, investigated links between financial and economic variables, and pricing strategies adopted by contractors. These studies built on the assumption that contractors could pursue pricing strategies through the choice of accounting methods.

Two other studies, by Greer and by Moses, investigated links between accounting choices and cost reduction (as measured by learning curves fit to cost data).

The central objective of this thesis is to further investigate the links between accounting choices and cost reduction experience on various Department of Defense (DoD) aerospace programs, using a different sample and more precise measures than those used in previous studies. To set the stage and provide the context for the analysis contained in this thesis, the four studies referred to above will be reviewed.

A. STUDY 1: EARLY DETECTION OF A SELLERS PRICING STRATEGY

In this study, Greer [Ref. 1] explores the effect of specific accounting methods employed by selected aerospace

contractors on that contractor's price reduction rates. In Greer's study the price reduction rate of program's were measured by learning curve slopes.

Greer hypothesized that a company's price reduction curve might be reasonably estimated as a function of a contractor's choice of accounting methods as reported in their annual report.

In his study, Greer assumed that aerospace contractors would either employ a penetration or skimming pricing strategy in bidding for government work. Greer describes penetration and then skimming as

> ...spreading product appeal rapidly through low initial pricing; then, once the market is penetrated, taking advantage of cost reductions and/or price increases to generate healthy profits. Skimming calls for high initial pricing followed by a careful series of price reductions designed to reap the maximum profit at each step. [Ref. 2: p. 6]

Skimming allows a contractor to recoup costs much more rapidly than the penetration pricing strategy.

It is clear that with a penetration pricing strategy initial unit prices will be high and have a nearly "flat" price reduction curve. Skimmers will have higher first unit costs and a steeper price reduction curve.

It is an accepted fact that over the life of an aerospace contract the development and production of the end item becomes more efficient and the cost per end item is continually reduced. This "learning" means that the cost to develop the first item is greater than each successive

follow-on item and that each successive end item is less costly to produce. But, the degree to which learning is apparent may depend on what accounting choices are used to measure costs.

Greer argued that use of the "last-in-first-out" method of accounting for inventory, or an accelerated method of accounting for depreciation would tend to recognize contract costs early and consequently be associated with a steeper cost reduction curve. Greer also examined a third accounting choice, the treatment of investment tax credit, but did not expect a significant relationship between this accounting choice and cost reduction.

Greer chose eleven different contractors and 27 different programs. Using 1982 annual reports he was able to determine accounting methods used by each company for depreciation, investment tax credit (ITC) and inventory. He also used a military aircraft cost handbook [Ref. 2] to compile learning curve slopes for each program. After statistical testing, Greer found his hypothesis to be statistically significant. The t-ratios were positive and statistically significant at the .05 level for both depreciation and inventory accounting choices. (ITC method choices were not statistically significant.) In short, accounting choices appear to be significantly associated with the degree of cost reduction experienced on programs.

The flaw in Greer's study is that he used accounting data from each company's 1982 annual report, though a majority of the programs studied were 1950's programs. In using recent accounting data for relatively older programs, Greer has assumed accounting methods have not changed in twenty to thirty years. This seems to be an unreasonable assumption. This thesis will use contractor accounting method data taken from annual reports for the same years as the programs in the sample. The practice of matching program years with accounting methods for those same years should result in a more precise test of the links between accounting and cost reduction.

B. STUDY 2: IMPACT OF ACCOUNTING METHODS ON LEARNING RATES

This Moses study, [Ref. 3] extended the investigation of links between accounting and cost reduction. While replicating Greer's empirical tests, the focus of the Moses study was on exploring the potential effects of accounting on cost reduction by conducting simulations. He also explored the role of inflation rates and program length as they impact the role of accounting choices.

As in the Greer study, Moses continued with the theme that earlier recognition of costs would be associated with relatively higher first unit costs and lower last unit costs. This earlier recognition of costs would result in a decreasing average unit cost and apparent learning. The opposite effect was expected of delayed cost recognition;

relatively lower unit cost for earlier produced units, but a flatter learning curve.

Throughout the study simulations were used to demonstrate the potential impact of accounting method choices on cost reduction rate. Choices in the areas of depreciation, capitalization or expensing of costs, and material costs were all examined.

1. Depreciation

It was demonstrated that an accelerated depreciation method choice would cause relatively more cost to attach to a program's early production units and less to later production. The effect of inflation on depreciation was also controlled. The result was that inflation had little effect on the difference between straight line and accelerated depreciation methods, but produced a steadily declining cost series in which learning appears to take place. The examples showed that (1) accelerated depreciation always leads to greater apparent learning than straight line, (2) the effect of depreciation on learning slopes is considerably greater for shorter project lengths, and (3) differences between the two methods are greater when learning rates are determined using nominal as opposed to inflation adjusted (constant) dollars.

2. Capitalizing or Expensing of Costs

Building on the depreciation example, it was found that expensing of costs produced effects on learning curves

analogous to accelerated depreciation and capitalization of costs produced effects analogous to straight line depreciation. The expensing of costs tended to show greater apparent learning while capitalization showed lesser (flatter) learning slopes. It was also demonstrated that the difference between the two methods was more pronounced when the program length was greater. Inflation was also controlled for and found to have a similar effect to the depreciation example.

Data on capitalization policy is, unfortunately, rarely available in a firm's annual or 10K reports. The study's findings demonstrated that the choice between expensing and capitalizing costs can, however, have a considerable impact on the cost reduction rate.

3. Material Costs

This section considered costs associated with material inventory. For inventory, whether inflation was controlled for or not, learning slopes were consistently lower for last-in-first-out (LIFO) than for first-in-first-out (FIFO) inventory methods. When the number of accounting periods were small the differences were greater, suggesting that the impact on learning rates is greatest for shorter programs. It was also shown that inventory method choice did not have as great an effect as depreciation or capitalization method choices.

4. Summary of Study 2

The simulations clearly demonstrated that accounting policies can potentially impact learning rates, and that depreciation and capitalization policy have more impact than inventory. It is also evident that, program length, and inflation, though not accounting variables, will impact learning rates.

Taken together, the Greer and Moses studies provide both simulation and empirical evidence that accounting choices and cost reduction on programs are related. The next two studies, reviewed by the researcher, assume that, given the potential to influence the degree of apparent cost reduction experienced on programs, contractors have a technique which can be used to pursue a pricing strategy. These studies investigated the association between various financial and economic variables, and contractor pricing strategies.

C. STUDY 3: DETERMINANTS OF CONTRACTOR PRICING STRATEGY

Another Moses study, [Ref. 4] looks at the relationship between a collection of variables, economic indicators and program characteristics, and pricing strategy. The general argument is that features of the economic environment and features of specific acquisitions programs provide motivations for contractors to pursue either penetration or skimming pricing strategies. In the study, measures to represent economic and program features were created. These

measures were then used to explain pricing strategy (as operationalized by price reduction curves).

As discussed in the first study, skimming is indicative of a greater cost reduction curve and penetration of a lesser cost reduction curve. In the following paragraphs some of the economic variables and program indicators featured in the study are discussed. Also, the pricing strategy Moses predicted each would produce, is presented.

Because inflation reduces the value of future dollars, firms were expected to prefer rapid returns in an inflationary economy. Since skimming tends lead to more rapid returns, higher inflation was expected to motivate a contractor to make accounting choices that would accommodate this skimming pricing strategy.

Longer program lengths spread out start-up and fixed program costs over a greater number of periods; they also ensure stable revenue flows for several future periods. It was predicted that the longer a program's expected length, the more apt a contractor was to use a penetration pricing strategy.

Commitment to the program was measured by the level of first year funding divided by the total required funding. It was hypothesized that the greater the percentage of the program funded in the first year, the more likely a contractor would be to use penetration strategy. This is

expected since likelihood of program curtailment declines with level government commitment to the program.

The extent to which the aerospace industry's capacity utilization is maximized was expected to be a motivator of pricing strategy choice. Low utilization means fixed costs must be spread over relatively fewer programs, while high utilization allows costs to be spread over relatively more programs. It was anticipated that firms with high utilization rates would have a stronger negotiating position and favor rapid return on investment and a skimming pricing strategy. Lesser utilization would increase fixed costs per program and motivate a penetration pricing strategy.

In first run programs some learning and some cost reduction may be expected. In follow-on programs (an updated version of a previously produced item), less learning and cost reduction would be expected. Follow-on programs were expected to yield flatter learning slopes.

Other variables such as program size, general economic condition, defense spending, and program value were also discussed in the study. The selection of variables that were reviewed lend themselves to uncomplicated data retrieval, and plausible means of measurement. These variables; inflation, program length, government program commitment, industry plant capacity utilization, and whether a program is a follow-on or first run program were reviewed here since they are used later in the thesis study.

In as much as these non-controllable variables may effect management motivation toward one or the other pricing strategy, they may also, indirectly effect cost reduction curves. Though these economic variables can not be contractor controlled, it is conceivable that management pursues pricing strategies based partly these variables. Given the possible indirect impact that these variables may have on cost reduction rates, it is reasonable to control for them in this study of the impact of accounting methods on cost reduction rates.

D. STUDY 4: FINANCIAL CONDITION AND THE DETECTION OF CONTRACTOR PRICING STRATEGY

In this McGrath and Moses study, [Ref. 5] the impact of a firm's financial condition on their choice of pricing strategy is explored. Similar to study 3, where economic variables and program characteristics were expected to influence certain pricing strategies, this study predicts that a firm's financial condition will motivate either a penetration or skimming pricing strategy. Measurement of a firm's financial condition was made through analysis of financial ratios. Many financial ratios exist, but the study focused on five broad categories representing five aspects of financial condition. Profitability (return on investment), short term liquidity, solvency (capital structure), activity (turnover), and capital investment were the measures used.

Profitability, as measured by return on investment, was expected to impact a firms choice of pricing strategy. It was argued that since executives are often compensated based on profit measures; the pricing strategy that is most likely to increase profitability would be selected. Therefore,a highly profitable firm would need highly profitable projects to keep profitability measures high, and would be most likely to choose skimming. Penetration would tend to reduce profitability in the short term and would hurt a highly profitable firm´s overall profitability.

Short term liquidity is important since new product initiation often requires substantial capital outlays. Firms with high liquidity would not be as "cash poor" as poor liquidity firms, and would be more likely to pursue a penetration pricing strategy. Cash poor firms would be expected to try to generate funds rapidly through a skimming pricing strategy.

Solvency measures the way a firm is structured. Some firms are highly leveraged and financed with relatively more debt, other firms rely on mostly equity financing. Those financed primarily by debt are less solvent and would probably have a higher cost of raising new capital. This was expected to lead to a preference for skimming.

Sales generated on assets is a measure of activity and is an indicator of the degree to which capacity is used. It was theorized that firms with low utilization would be able to

increase the probability that their excess capacity is put to use through selection of a penetration strategy.

Investment in capital would increase the level of fixed costs. Major investment in new equipment for a program would motivate penetration since this strategy would be most likely to ensure use of the new assets. Firms with existing capacity and with little need for expansion through new equipment purchase would be more likely to skim.

As in previous studies the learning curve slope was used to indicate the pricing strategy used. The models employed in this study were designed to establish an association between pricing strategy and financial condition. In general the model demonstrated that there was a significant association between pricing strategy and financial ratios. As was observed in study 3, variables (in this case financial ratios) provide motivation for management to pursue certain pricing strategies.

The previous two studies demonstrate that various financial and economic variables motivate contractors to pursue certain pricing strategies. Some of these variables the contractor can't control, and some he has only limited control over. The contractor can, however, influence the degree of apparent cost reduction experienced on programs, through choice of accounting methods as was demonstrated in the first two studies reviewed above.

E. AREA OF THESIS RESEARCH

In general this study addresses the same question as the Greer study reviewed earlier: What is the relationship between accounting choices and cost reduction experienced on government programs? The research differs from the Greer study in three ways. First, data to measure accounting choices will be taken from annual and 10K reports published at the same time aerospace programs were active, rather than from 1982 reports as in the Greer study. Second, a larger sample will be investigated. Third, control variables, suggested by some of the studies reviewed above will be included in the analysis. These include the variables related to inflation, program length, capacity utilization, program funding and whether the program was a follow-on or first model program.

By adopting these methodological refinements it is anticipated that a fuller understanding of the role of accounting on cost reduction in government programs may result.

The remainder of the thesis is organized as follows: The next section, Chapter II, introduces the concept of learning curves. This provides the necessary background to understanding the use of learning curve slopes as a measure of cost reduction. Chapter III explores the impact of accounting methods on cost reduction. This lays the groundwork for hypotheses to be made about the effects of

accounting methods on cost reduction for specific aerospace programs. Chapter IV details the data collection process, sample selection and choice of accounting and control variables used in the study. Chapter V reviews the statistical models, statistical testing, and analyzes the results. Chapter VI will summarize the process and reach the conclusion of the study.

II. LEARNING THEORY

This chapter introduces learning theory. The presentation will include a brief history of learning theory, an explanation of how learning curves are computed, how they are used in the aircraft industry, and why they are important to this study. At the conclusion of this chapter, the significance of learning slopes and their relationship to cost reduction rates should be clearly understood.

Learning curve theory describes the reduction in per unit costs or labor hours, required to produce the end item, as volume increases. The notion of learning curves was first recognized by industrial optimizers who noticed that individuals performing repetitive tasks tended to display an increased rate of execution. Use of learning curves is particularly applicable in explaining cost reduction in the aircraft industry. A basic knowledge of learning theory will be necessary if the statistical analysis in this thesis is to be understood.

T. P. Wright was a pioneer in the study of learning theory in the aircraft industry. He published an article on learning theory, [Ref. 6] that demonstrated that with increasing aircraft production, the cumulative average of direct labor input per unit decreased in a regular pattern. The pattern existed as an exponential relationship. The

independent variable is the number of units produced (volume) and the dependent variable is cost per unit of production.

The common mathematical expression for the learning curve phenomenon is:

$$C = AX^B$$

C is the average cost per unit to produce the Xth unit; A is the cost of the first unit, and X is the cumulative number of units. The exponent B represents the ratio of the natural log of slope over the natural log of two. For declining costs the ratio that B represents will be negative, for no cost reduction it will be zero, and for increasing cost B will be positive. The following example illustrates the learning curve with sample data:

USE OF THE LEARNING CURVE
Data for 90% curve

Sequential Unit #	Cost @ Unit #	Chng in Cost @ doubled quantity	% difference
1	10,000		
2	9,000	1,000	10%
4	8,100	900	10%
8	7,290	810	10%
16	6,561	729	10%

In the above example the variable A is represented by the "Cost @ unit #" column, X is the sequential unit #, and B is a function of the percent difference. B is found by

subtracting the percentage difference, in cost with each doubling of production, from one (1). That number is the slope (S) and B is computed by the formula:

$$B = \ln S / \ln 2$$

The above ratio implies that with each doubling of units produced the average cost of each unit is reduced by (1 - the slope), which is 10 percent for this example.

Given T. P. Wright's early work in aircraft manufacture, it is not surprising that learning curves are of considerable interest to both aircraft manufacturers and their customers. Application of the learning curves to manufacturing has proven to be particularly useful in analysis of cost reduction.

Learning theory studies have often emphasized the rate of reduction in labor hours required to produce the end item. More careful observation would reveal that increased worker dexterity is only one of the reasons for reduction in labor hours.

Given fixed labor wage rates and an increased rate of task completion, some cost reduction, due to reduced labor hours per unit would be realized over time. There are, however, a number of other reasons for cost reduction in repetitive processes. Increased labor efficiency, improved assembly line or plant layout, more efficient manufacturing equipment, and less material through improved scrap and waste rates are all reasons for cost reduction. To generalize

then, a cost reduction curve might not only be associated with learning, but also with greater production efficiencies. The learning curve, which is a measure of cost reduction, can also be referred to as a cost reduction curve.

This thesis will use known learning curve slopes, as collected from U.S. government missile and airplane cost handbooks, for each program studied. The slopes will be used as measures of cost reduction rates. Relationships between a contractor's choice of accounting methods and the cost reduction slope will be tested.

This chapter has explained the history behind and computation of learning slopes. It has also addressed the importance of learning theory in the aircraft industry and identified how learning slopes will be used in this thesis study as measures of cost reduction. In the next chapter the potential impact of accounting method choices on cost reduction slopes are examined.

III. IMPACT OF ACCOUNTING METHODS ON COST REDUCTION RATES

There are many different accounting methods that agencies allow firms to use in accounting for costs. Agencies like the Financial Accounting Standards Board (FASB), the Cost Accounting Standards Board (CASB) and the Securities and Exchange Commission (SEC) are responsible for setting accounting standards. Generally Accepted Accounting Principles (GAAP), as defined by the FASB and adhered to in U.S. industry, allow some flexibility in accounting. Under GAAP, accounting areas such as depreciation, inventory, investment tax credits (ITC), and capitalization or expensing of costs may be handled in more than one way. The purpose of this chapter is to discuss some of the major accounting areas that affect the measurement of costs incurred on large government contracts. Also how a firm's use of either liberal or conservative accounting methods might effect the cost reduction rate in multi-year government programs.

A. BACKGROUND

The primary goal of financial accounting and financial statements is to provide accurate, reliable, quantitative financial information about a business in a timely fashion. Preparers and users of financial statements, however, are rarely in complete agreement on what this means. One of the key FASB roles is the responsibility for studying accounting

problems and issuing opinions that serve as bench mark standards for business financial reporting. In government contracting, though, further accounting standards have been developed.

For cost-type negotiated government contracts over $100,000 defense contractors and subcontractors are obligated to account for costs under Cost Accounting Standards Board (CASB) procedures.

> The U.S. Congress created the Cost Accounting Standards Board (CASB) in 1970 to promulgate cost accounting standards (CAS's) designed to achieve uniformity and consistency.... CASB requirements are also adhered to in most non-defense cost-type contracts. [Ref. 7:p. 18]

Though the CASB is now defunct, the standards penned by the board members are still adhered to today.

All standards restrict methods of accounting to specific principles, however no standard can cover all eventualities. Within limits, GAAP allow firms a number of accounting options that will affect costs, and many of these options are built into the CAS's. The intent here is to discuss several areas in which CASB standards permit accounting judgments to be exercised or choices to be made between alternative accounting procedures. To the extent that these accounting choices effect the timing of cost recognition, they have potential ability to influence the measurement of unit costs over time and hence, influence the apparent cost reduction experienced on government contracts.

The CASB standards cover areas such as Cost Accounting Periods (#406), General and Administrative Expenses (#410), Inventory Methods (#411), Depreciation Methods (#409), Capitalization Criteria (#404), Home Office Expenses (#403), Engineering Costs (#420), Service Center Costs (#418), and Cost of Money associated with Facilities (#414,417). The CAS's establish guidelines, but within these regulations, there is room for interpretation and flexibility.

CAS #406 (Cost Accounting Period), in addressing timing of costs, sets the fundamental requirement as;

> A contractor shall use his fiscal year as his cost accounting period except that:
>
> (1) Costs of an indirect function which exist for only a part of a cost accounting period may be allocated to cost objectives of that same part of the period on the basis of data for that part of the cost accounting period if the cost is material in amount, accumulated in a separate indirect cost pool, and allocated on the basis of an appropriate direct measure of the activity or output of the function during that part of the period.
>
> (2) An annual period other than the fiscal year may, upon mutual agreement with the Government, use as his cost accounting period a fixed annual period other than his fiscal year, if the use of such a period is an established practice...and is consistently used....
>
> (3) A transitional cost accounting period other than a year shall be used whenever a change of fiscal year occurs.
>
> (4) Where a contractor's cost accounting period is different from the reporting period required by Renegotiation Board regulations, the latter may be used for such reporting. [Ref. 8:p. 164]

Cost Accounting Standard #406 then delineates a series of exceptions to the fundamental requirement which allow

flexibility in determining what period specific costs will be recognized as incurred.

Another area of flexibility is the determination of allowable costs. Allowable costs are those that have been determined to be applicable to a specific program or contract. The CAS's do not always address the question of a cost's allowability, but rather state how to account for a cost once it is determined to be allowable or unallowable. CAS #405 (Accounting for Unallowable Costs), states "This standard does not govern the allowability of costs. This is a function of the appropriate procurement or reviewing authority." [Ref. 9:p. 153]. Other standards, which regulate the allowability of costs, may permit a contractor flexibility in determining which costs are allocable to specific contracts. This flexibility will influence actual costs and potentially the cost reduction rate. Allowability of cost, however, will not be explored in this study.

The timing of costs as influenced by accounting choices will be the primary thrust of this study. The period in which costs are recognized and included in projects, will effect the costs associated with the production unit. Choice of accounting methods; recognizing more cost earlier or later, will effect the slope of the cost reduction curve.

As mentioned previously, there are a host of accounting methods that can be used to account for a firm's assignment of costs. A discussion of some of these and their effect on

the cost attributed to goods or services produced, is intended to provide an awareness of the implications of various methods.

B. DEPRECIATION

> The term depreciation as used in accounting, refers to the process of allocating the cost of a depreciable tangible fixed asset to the accounting periods covered during its expected useful life. [Ref. 10:p. 517]

For many, depreciation has a general connotation of the amount of reduction in property value in a given time period. Depreciation has been defined by the American Institute of Certified Public Accountants (AICPA) in its **Accounting Terminology Bulletin No. 1**:

> **Depreciation accounting** is a system of accounting which aims to distribute the cost or other basic value of tangible capital assets, less salvage value (if any), over the estimated useful life of the unit in a systematic and rational manner. It is a process of allocation not valuation.
>
> **Depreciation for the year** is the portion of the total year. Depreciation can be distinguished from other terms with specialized meanings used by accountants to describe asset cost allocation procedures. Depreciation is concerned with charging the cost of man-made fixed assets to operations. [Ref. 10:p. 517]

In deciding upon the amount of depreciation to expense in a given period a firm must (1) determine the cost of the asset to be depreciated, (2) estimate its useful life, (3) estimate the salvage value at the end of the useful life, and (4) determine the method of depreciation to be used. All of the above variables will effect the amount of depreciation

expense in a given period, the cost of goods sold and the cost reduction rate.

In determining the cost of the asset, a firm usually uses the purchase price. If, however, the asset was received as payment of a debt, or as compensation in trade for another asset, other methods of valuation must be used. If an asset is purchased new, there isn't much room for interpretive valuation, but in the second case, where assets are traded, there is some latitude in the valuation choice. Though asset valuation is not an exact science, estimates of useful life, salvage value and depreciation methods tend to be less exact.

Shorter estimated useful life, low estimate salvage value and accelerated depreciation methods will allow a firm to maximize depreciation expense in the early years of the asset and allow a dramatic decrease in the cost of goods manufactured over the life of a contract or program. An illustration of how a firms depreciation expense could vary for the same asset given different assumptions is presented below:

	Assumption A	Assumption B
Asset Cost:	10,000	10,000
Estimated useful life:	5 years	8 years
Estimated salvage value:	0	2,000
Depreciation method:	SYD*	Straight line

* Sum of Years Digits

	Year 1	Year 2	Year 3	Year 4
Depreciation Expense A:	3333	2667	2000	1333
B:	1000	1000	1000	1000

It can be seen from the illustration on the preceeding page that the combination of shorter estimated useful life, minimum salvage value and accelerated depreciation will yield a considerable larger depreciation expense in the first years of an assets life. This treatment tends to show a rapid decrease in cost and, if used for a program, would contribute toward a steeper downward cost reduction curve. Consistent with the relatively higher depreciation expense in the first few years of an asset's life, it follows that shorter duration projects would experience greater cost reduction when accelerated depreciation methods are employed.

Once the value of the asset is known, the estimated useful life and depreciation method variables have the greatest effect on the cost associated with depreciation expense. Also accounting changes, by a firm, to alternate depreciation methods or changes in estimated useful life of a class of assets, such as buildings, will effect chargeable depreciation costs.

C. INVENTORY

Inventories are another source of cost, and the method by which they are accounted for can have an effect upon the costs associated with government contracts. The FASB and SEC require that a firm use one of a number of permissible inventory methods on a consistent basis, unless the firm canmake a case for an accounting change. **Accounting research bulletin No. 43**, chapter 4 states:

> The primary basis for accounting for inventories is cost... as applied to inventories, cost means in principle, the sum of the applicable expenditures and charges directly or indirectly incurred in bringing an article to its existing condition and location. [Ref. 11]

> At least five valuation bases are used... acquisition cost, current cost measured by replacement cost, current cost measured by net realizable value, lower of acquisition cost or market, and standard cost. [Ref. 12:p. 330]

With all inventory methods, the FASB requires firms to reduce the value of inventory to the lower of cost or market. Other considerations in inventory accounting are the frequency of computing inventory changes, periodically or perpetually, and the cost flow assumption which traces costs into and out of inventory.

Inventories include work-in-process (WIP), contracts-in-process (CIP), raw materials, finished goods, and manufacturing supplies. In WIP and CIP inventory accounts, valuation is often complicated by the addition of other costs such as overhead, labor, research and development, and general and administrative costs.

Cost flow assumptions used in accounting for inventory costs include, first-in-first-out (FIFO), last-in-first-out (LIFO), weighted average, specific identification and others. Most firms use FIFO, LIFO or average cost so the discussion will be limited to these.

The FIFO inventory method assigns the costs of the oldest inventory to cost of goods manufactured (CGM), or cost of work-in-process (WIP), and assigns the most recently acquired

purchases to inventory on hand. Since the oldest inventory has usually been purchased the earliest, given inflation, it will often be valued at significantly less than it could be bought for at current prices. The FIFO treatment tends to value cost of goods sold manufactured lower, and value inventory on hand higher than other methods.

The LIFO inventory method assigns the costs of the most recently acquired inventory to CGM, or cost of WIP, and the costs of the oldest items to inventory on hand. This method, at the opposite extreme from FIFO, will tend to yield greater values associated cost of goods manufactured and lower values associated with inventory on hand.

LIFO inventory costs will tend to reflect current prices and will be higher than FIFO inventory costs in an inflationary economy. There is a condition, however, that will yield artificially low cost of goods manufactured. In LIFO inventory accounting "LIFO layers" are built up over time as a business expands and inventory grows. Since the last inventory purchased is the first to be used, the oldest inventory can be very old. These old " LIFO layers" are carried at historical cost which can be many times less than what the same inventory would cost in the current market. If inventories are allowed to fall, so that these "LIFO layers" must be tapped, the cost of goods manufactured will be artificially low. By letting inventories fall, a firm could

assign much less cost to goods manufactured and cause a steeper cost reduction curve.

The moving average inventory method is a compromise between FIFO and LIFO. In the average method the inventory value is recomputed after each purchase. In an inflationary (normal) economy, inventory unit costs will continue to climb. As purchases are made, the cost of the new purchase and cost of the old inventory balance are added together and divided by the total number of units to give a new unit cost.

D. CAPITALIZATION OR EXPENSING OF COSTS

CASB standard 404 sets guidelines for manufacturing contractors, requiring the establishment of a policy on capitalization of asset costs. When a cost is capitalized it is treated as an asset and charged to expense in several different accounting periods via depreciation. The number of periods usually corresponds to the estimated life of the asset being capitalized. The alternative to capitalization is immediate expensing, in which case the cost is assigned to the current period in which the expenditure occurs.

Capitalization policy as set forth by CAS 404 requires the contractor to set minimum service life, and minimum cost standards at two years or less, and $1000 or less respectively. If both standards are met, assets costs are capitalized.

> Assume manufacturer A sets a policy of capitalizing items which cost more than $1000 and have a service life of more than one year. Assume manufacturer B

sets limits of $500 and two years. An asset costing $750 with a service life of 5 years would be capitalized by B and expensed by A. An asset costing $1500 with service life of 18 months would be capitalized by A and expensed by B. In short, manufacturers have some ability to influence the timing of costs through the designation of capitalization criteria. [Ref. 3:p. 8]

Contractors have some freedom in classification of assets as well. Assets with similar functions which are used together may be grouped together or separately. Assume a contractor buys a networked phone system. This contractor has established a capitalization policy that sets the minimum service life at two years and the minimum cost of the asset at $1000. Each phone instrument costs $200, and six instruments are needed for the network. If each phone is considered separately, no instruments would be capitalized, but classified together as one asset, the entire $1200 would be capitalized. The way in which a contractor classifies assets allows additional ability to influence timing of costs.

In the above example let's assume that the asset has an estimated useful service life of four years. The following illustration demonstrates the effect of grouping the phones together or independently:

			Annual Costs			
	Asset	Cost	YR1	YR2	YR3	YR4
1.	6 Phones (grouped together)	$1200	$300	300	300	300
2.	6 Phones (each independent)	$1200	1200	0	0	0

From the illustration it is clear that the first capitalization policy allows the firm to expense only one-fourth of the asset cost in each of the four years of the asset's service life. The second policy of expensing the entire $1200 cost will show a sharp drop in cost for this asset from year one to year two. If the estimated useful life were 12 years, the first policy would allow $100 annual costs and the effect would be even sharper for the second expensing alternative.

E. COST OF MONEY ASSOCIATED WITH FACILITIES

CAS's 414 and 417 address the cost of money associated with facilities. Before a contractor begins a large scale defense contract, additional production facilities may be required. Whether new facilities are constructed or existing facilities are used, there is a cost of capital associated with their use. The cost of financing the construction of the facilities, or the cost of the capital tied-up in the use of existing facilities is an allowable cost.

A contractor's financial leverage, ability to meet long and short term obligations, and other factors will influence the cost of borrowing money. Regardless of the cost of capital paid by the contractor, CAS's 414 and 417 set the allowable cost of money "... based on interest rates determined by the Secretary of the Treasury pursuant to Public Law 92-41 (85 Stat. 97).", [Ref. 13:p. 150] Pursuant

to the CAS, the contractor may only compute cost of capital at the treasury rate.

Like many of the other previously discussed accounting areas, there are a number of methods by which to account for the cost of capital. Unlike accounting areas such as depreciation and inventory the different methods for computing cost of capital do not generate a materially different result. So, even though the method of computing cost of capital won't materially affect the cost reduction rate, the amount added to the asset, in the form of cost of capital, to be capitalized can be significant.

F. INVESTMENT TAX CREDITS

> To provide a stimulus for the acquisition of new capital equipment, the federal government reduces income taxes otherwise payable in years when a firm purchases qualifying equipment. Even though some companies account for this cash savings in income taxes over the life of the equipment, the cash flow all occurs in the year the qualifying equipment is put into operation. [Ref. 14:p. 371]

A firm has a choice of accounting treatment for investment tax credits (ITC). A firm can elect to recognize the investment tax credit all at once, as a reduction of tax expense (flow-through method), or defer the investment tax credit and recognize it a little at a time over the estimated life of the asset (deferral method). The investment tax credit reduces the amount of income tax expense, so that under the flow through method the entire tax benefit is assigned to the first year. This treatment has the effect of

reducing expenses in the first year. Using the deferral method only a proportional fraction of the ITC is recognized in each year of the assets expected life. This has the effect of spreading the reduction in tax expense over a larger number of years.

G. CONSERVATIVE VERSUS LIBERAL ACCOUNTING

Throughout this chapter different accounting methods for various areas have been examined. Hypothetical scenarios were developed which demonstrated how the choice of accounting method can effect the timing of costs. A firm's choice of accounting methods can be termed liberal or conservative. Liberal accounting choices would represent delayed cost recognition and conservative choices, early cost recognition.

For the accounting areas discussed, straight line depreciation, FIFO inventory method, immediate recognition of investment tax credits, and capitalization of asset costs represent liberal procedures. Conservative procedures would be accelerated depreciation, LIFO inventory method, deferral of investment tax credit handling, and immediate expensing of asset costs.

Though investment tax credits would appear to have some effect on cost reduction rates the Cost Accounting Standards Board does not allow the choice of ITC allocation method to impact determination of cost for government contracts. Investment tax credit treatment then, is not directly

relevant to government contracts, but may be relevant as an indicator of conservative or liberal accounting tendencies. The way in which a firm tends to handle accounting choices may be an indication of their general conservatism or liberalism.

The impact of how each liberal or conservative choice could affect the timing of costs was examined in this chapter. It follows that the combination of all conservative or all liberal accounting policy could compound the timing effects and perhaps dramatically affect the cost reduction curve.

H. SUMMARY

Through discussion and examples, differing accounting treatments, within each of several accounting areas, have been examined. The purpose been to show that the choice of accounting methods can affect the timing of costs and consequently the cost reduction curve.

The next chapter begins the empirical portion of the study. As indicated previously, the central empirical question is whether there is evidence of a relationship between accounting choices and cost reduction experienced on actual defense programs. While this chapter has discussed the potential impact of many accounting choices on cost reduction, the empirical portion of the study will focus on investigating the effect of selected accounting choices for which data could be collected.

IV. DATA: SAMPLE, COLLECTION, AND VARIABLES

This chapter addresses sample selection, data collection, and the selection and measurement of variables. The process of choosing the original sample is discussed and, data collection, including sources and associated data retrieval problems, are covered. Finally the rationale behind the choice and definition of the variables used for the statistical tests, is examined.

The sample used in the thesis research was selected from Department of Defense (DoD) missile and airplane program samples taken from some of the past studies reviewed in chapter I. The intent of the sample choice was to include a large variety and number of aerospace firms and programs over a broad time span. The larger sample was expected to yield an improved representation of aerospace firms and programs under contract with DoD.

A. THE SAMPLE

The initial sample included all DoD missile and airplane programs over a three year period beginning in 1949. A minimum three year length was generally necessary to calculate a cost reduction slope. The original list included 60 programs and 16 companies. Table 4.1, on the following page, lists each company with project names and years.

TABLE 4.1

ORIGINAL SAMPLE OF AEROSPACE PROGRAMS

	Company	Project	Years
1.	Bell Helicopter	AH 1G	66-71
2.	Bell Helicopter	AH-1S	75-80
3.	Bell Helicopter	AH-1T	76-78
4.	Bendix	RIM-8E	61-66
5.	Boeing Co.	B-47BE	49-53
6.	Boeing Co.	B-52G	57-59
7.	Cessna Aircraft Co	A-37B	67-73
8.	Fairchild	A-10A	73-82
9.	General Dynamics	F-102A	53-57
10.	General Dynamics	F106A/B	57-59
11.	General Dynamics	RIM-2D	61-64
12.	General Dynamics	RIM-2E	61-66
13.	General Dynamics	RIM-24B	61-66
14.	General Dynamics	RIM-66A	66-70
15.	General Dynamics	RIM-67A	66-74
16.	General Dynamics	F-111A	67-69
17.	General Dynamics	F-111F	70-74
18.	General Dynamics	RIM-66B	71-80
19.	General Dynamics	AGM-78D	73-75
20.	General Dynamics	RIM-67B	73-82
21.	General Dynamics	FIM-92A	78-81
22.	General Dynamics	F-16A	78-82
23.	General Dynamcis	RIM-66E1	80-82
24.	General Dynamics	BGM-109	80-82
25.	Grumman	F-9F/H	51-52
26.	Grumman	A-6A	61-69
27.	Grumman	A-6E	70-79
28.	Grumman	F-14A	71-82
29.	Lockheed Aircraft	F-104A/B/C	56-57
30.	Lockheed Aircraft	P-3A	60-64
31.	Lockheed Aircraft	P-3B	65-67
32.	Lockheed Aircraft	P-3C	68-82
33.	Lockheed Aircraft	S-3A	72-76
34.	Martin Marietta	B-57B/C/E	52-55
35.	McDonnell Douglas	F-101A/B/C	54-59
36.	McDonnell Douglas	A-4B	55-57
37.	McDonnell Douglas	A-4C	57-62
38.	McDonnell Douglas	F-4A/B	59-66
39.	McDonnell Douglas	A-4E	61-64
40.	McDonnell Douglas	F-4D	64-66
41.	McDonnell Douglas	F-15A	73-79
42.	McDonnell Douglas	F/A-18A	79-82
43.	Motorola Inc.	AIM-9C	61-67
44.	N. Amer. Aviation	F-86D	51-53
45.	N. Amer. Aviation	F-86F	51-53
46.	N. Amer. Aviation	F-1B/C/MF-1	52-55
47.	N. Amer. Aviation	F-100A/C	52-55
48.	N. Amer. Aviation	F-100C	53-55
49.	N. Amer. Aviation	F-100D	54-55
50.	Northrop Corp.	F-89D	51-54
51.	Raytheon	AIM-7E	61-62
52.	Raytheon	AIM-7F	68-80
53.	Raytheon	AIM-7M	80-82
54.	Republic Aviation	F-84F	51-53
55.	Republic Aviation	F-105B/D	57-62
56.	LTV (Vought)	F-8A/B/C	55-58
57.	LTV	F-8D/C	58-63
58.	LTV	A-7A/B	65-67
59.	LTV	A-7E	67-69
60.	LTV	A-7D	68-75

An attempt was made to collect company 10K reports for each program. In the absence of 10K reports, annual reports were used. The reports were used to collect information on company accounting methods. The methods were coded and used as predictor variables (accounting variables) in the statistical tests.

The first list of firms, programs, and cost reduction slopes were compiled from airplane and missile cost handbooks [Refs. 2 & 15]. A few of the program slopes were unavailable and they were eliminated from the sample. After compilation of this initial sample and learning slope data, the primary data collection could begin.

B. DATA COLLECTION

The data collection phase required collection of over 200 annual or 10K reports. Annual reports and or 10K reports for the firms in the sample were collected from the Naval Postgraduate School and University of California, Berkeley, libraries and selected aerospace firms. Since 10K reports tend to disclose more accounting information than annual reports, the initial concentration was on 10K report retrieval.

Many of the 10K's were available on microfiche from the Naval Postgraduate School. Others were available through inter-library loans. In general 10K reports only became available 20 years ago since the Securities and Exchange Commission (SEC) is only required to hold them that long.

Prior to 1968 it was not a common practice to microfiche 10K reports.

Annual reports were primarily used for data collection prior to 1968. The University of California at Berkeley provided them for the sample. Since the reports could not leave the library, pertinent financial data was reproduced. Also, Lockheed Airplane Company supplied annual reports for 1977-1982. Neither annual reports or 10K reports could be found for some of the firms. Attempts were made to locate reports through the Naval Postgraduate School search computer, the Securities and Exchange commission (SEC) and Harvard University. It was discovered that after holding 10K or annual reports for 20 years, the SEC sells many of them to Harvard University. The cost of obtaining those, however, was considered prohibitive. In addition to cost, the data would likely have been of limited research value, since the reports needed were 1950′s era, an era of typically limited financial disclosure.

After all the data was collected and assembled, each year′s annual report or 10K report was inspected for disclosure of accounting methods used by the firm. Initially, each report was examined for a wide variety of accounting information. After a number of reports were scrutinized, however, it became clear that common data for all firms and years would only be available for certain accounting areas. Inventory method, depreciation method, and

investment tax credit (ITC) treatment were determined to be three accounting areas generally available. Since the reports generally disclosed information for these three areas, they were the only data used in the statistical testing.

Other data on economic, industrial conditions, and program characteristics were also collected for the study. Virtually all of this information had been previously compiled by Dr. Moses for past studies and was made available, for use in this study. Information on program length, inflation, time trend, initial government commitment to the program, aerospace industry capacity utilization, and whether the program was a follow-on or original model program were collected.

From the data collected, the dependent (learning curve slope) variable, the primary independent explanatory variables representing accounting choices, and control variables were developed for use in the statistical tests. The next section discusses variable development.

C. THE VARIABLES

Other than for the dependent slope variable, which are tabulated in the airplane and missile cost handbooks [Refs. 2 & 15], specific measures were not directly available. Definitions and values had to be developed for these variables. Variable development is discussed in the following paragraphs.

1. Predictor Variables (Accounting Variables)

The primary emphasis in this study is on the effect of accounting methods on cost reduction rates. As indicated earlier, cost reduction rates are measured by learning slopes. In order to test the associations between accounting methods and cost reduction rates a measure for the three accounting methods had to be developed.

Dr. Greer in his study [Ref. 1:p. 10], developed a value system for the accounting variables, depreciation, inventory and investment tax credit (ITC). His coding methodology was employed for this study. The coding for the variables is explained individually.

a. Depreciation (DEPR)

Chapter III of this thesis showed that an accelerated depreciation method would cause relatively more cost to attach to earlier production units. This would tend to cause the learning slope to appear steeper. A value of (1) was assigned to accelerated depreciation. Straight-line depreciation was shown to produce the opposite effect and this depreciation method received a (5). Firms using both methods were assigned a (3).

b. Inventory (INV)

Chapter III also demonstrated that given a normal inflationary environment, the last-in-first-out (LIFO) inventory method caused earlier recognition of the rising costs associated with raw materials and parts. This earlier

cost recognition would also tend to produce a steeper learning slope. The LIFO method was assigned a value of (1). The first-in-first-out (FIFO) inventory method received a (5), and the average method a (3).

c. Investment Tax Credit (ITC)

The accounting method chosen for investment tax credit was not expected to directly effect the learning slope since income tax is not an allowable cost in government contracts. Recall from chapter III, however, that firms may be characterized in their choice of accounting methods as being "liberal" or "conservative". The ITC choice can be conceived of as a variable which may reflect a firm's tendancy toward the use of liberal or conservative accounting. Thus, the ITC variable may serve as a proxy for other (unobservable) accounting choices. The flow through method of accounting for ITC received a (5), the deferral method a (1).

For all of the accounting variables, if the firm used a combination of methods, the combination was weighted linearly, and assigned an appropriated value.

2. The Control Variables

The other variables used in the statistical tests were developed to control for other factors which might influence cost reduction curves. As noted in chapter I of this thesis, some of the earlier studies revealed an association of variables reflecting economic conditions,

contractor financial condition and program characteristics with the cost reduction slopes. In general, each of the control variables can be expected to have some effect on cost reduction rates experienced on programs. It is possible that associations between the accounting variables and cost reduction rates may be obscured because of differences in cost reduction rates caused by other factors. Inclusion of control variables in some tests will serve to control for these other factors and perhaps lead to a more refined analysis of primary relationship of interest, which is the association between cost reduction and accounting choices. Each control variable will be explained seperately.

a. Program Length (PLENGTH)

The simulation study conducted by Moses and reviewed in chapter I established that the degree to which cost reduction slopes are potentially affected by accounting choices depends on the length of time over which the cost reduction slope is calculated. Program length, the difference between the starting year and ending year for a program, measures this period of time.

b. Inflation (INFL)

The previously discussed simulation study also demonstrated that the degree to which accounting choices effect cost reduction slopes is contingent on the degree of inflation underlying the cost incurrence over time. Controlling for inflation may better extricate the role of

the accounting choices. The measure for inflation was chosen as the industrial Producers Pricing Index (PPI) for the end year of a program minus the PPI for the start year, divided by the program length. A base year of 1967 with a value of 100 was used so that the PPI value for pre 1967 years was lower than 100, and greater than 100 for post 1967 years. For example if a programs end year PPI was 312, its start year PPI 126, and program length was nine years, the value for inflation would be:

$$(312 - 126)/9 = 20.67$$

c. Time Trend (TIMETRND)

The time trend was a variable that measured the passage of time. Technology changes over time, as do other circumstances associated with production. Prior research has shown a broad trend over the last few decades toward less cost reduction (flatter slopes) experienced on government aerospace programs. For this reason it was felt that the passage of time should be controlled. Accordingly the start year of each program was used as the value for each time trend variable.

d. Aerospace Industry Capacity Utilization (UTIL)

The level of utilization of plant capacity in the aerospace industry is an available statistic. The overall industry average is on file with the Federal Reserve Board. Capacity utilization is included as a control because of its potential effect on cost reduction. With higher capacity

uitlization, fixed costs are spread over greater output, reducing unit costs. If capacity utilization increases over the life of a program, later units produced may have lower fixed costs allocated to them, resulting in apparent cost reduction.

Capacity utilization was measured at the starting and ending years for each program. Start year capacity utilization was substracted from the end year capacity utilization (and divided by program length) to arrive at an approximate measure of the average change in capacity utilization over the program's life. Positive values for capacity utilization are consistent with a tendancy toward increasing capacity utilization.

e. Follow-on Program (FOP)

The "FOP" variable is used to denote the program as either an original model (FOP = 0) or a follow-on program (FOP = 1). Since it was expected that more learning would occur on original than follow-on model programs, this variable was designed to control for the connection between cost reduction rate and the "FOP" category.

f. Plane or Missile Code (PMCODE)

Similar to the "FOP" variable, which distinguishes between original and follow-on programs, the Plane/Missile code differentiates between airplane and missile programs. Manufacture of airplanes was assumed to differ from that of missiles. So, it is conceivable that

cost reduction rates would vary, all other things being equal, depending on whether the program was for an airplane or a missile.

Programs were given a code of (1) if the program represented an airplane, or (2) if they represented a missile. This was done so that statistical tests could be run on the whole sample and the subsets of planes or missiles.

D. DATA PROBLEMS AND FINAL SAMPLE

There were a few problems encountered in the data collection phase. Some of the older (1950's and 1960's) annual reports did not disclose certain accounting methods that were of interest in this study. In some cases disclosure was not made for depreciation method, investment tax credit treatment, or inventory. If accounting methods could be reasonably deduced, they were included in the data set. If not, the variable was omitted. Use of a variable with a value that matched the value found for preceding and succeeding years was considered reasonable. For example, if straight-line depreciation was disclosed for 1963 and 1965, then straight-line was assumed for 1964.

Table 4.2, on the preceeding page, tabulates the final sample with all variable values. for 12 firms and 45 programs.

TABLE 4.2

SAMPLE OF AEROSPACE PROGRAMS WITH ASSOCIATED VARIABLE VALUES

ID	CNAME	PNAME	PLNTH	SLOPE	DPR	ITC	INV	FOP	INFL	TTRND	UTIL	PMCODE
1	BOEING	B-47BE	4	0.916	-	-	3	0	-	49	0.130	1
2	BOEING	B-52G	2	0.869	-	-	3	1	1.00	57	0.067	1
3	CESSNA	A-37B	6	0.935	3	5	3	0	4.33	67	-0.028	1
4	FAIRCHILD	A-10A	9	0.963	3	5	3	0	20.67	73	-0.006	1
5	GEN DYN	F-102A	4	0.724	5	-	-	0	1.25	53	-0.015	1
6	GEN DYN	F-106A/B	2	0.837	3	-	-	0	1.00	57	-0.067	1
7	GEN DYN	RIM-2D	3	0.976	1	1	-	0	0.00	61	0.443	2
8	GEN DYN	RIM-2E	5	0.930	1	1	-	1	0.80	61	0.047	2
9	GEN DYN	RIM-24B	5	0.923	1	1	-	0	0.80	61	0.047	2
10	GEN DYN	RIM-66A	4	0.763	1	5	-	0	2.75	66	-0.055	2
11	GEN DYN	RIM-67A	8	0.825	1	5	3	0	6.88	66	-0.020	2
12	GEN DYN	F-111A	2	-	1	5	-	0	3.00	67	-0.045	1
13	GEN DYN	F-111F	4	1.115	1	5	3	1	11.00	70	0.015	1
14	GEN DYN	RIM-66B	9	1.135	1	5	3	1	17.89	71	0.026	2
15	GEN DYN	AGM-78D	2	1.088	1	5	3	1	23.00	73	-0.015	2
16	GEN DYN	RIM-67B	9	1.041	1	5	3	1	20.67	73	-0.006	2
17	GEN DYN	FIM-92A	3	-	1	5	2	0	31.33	78	-0.002	2
18	GEN DYN	F-16A	4	0.954	1	5	2	0	25.50	78	-0.026	1
19	GEN DYN	RIM-66E1	2	1.089	1	5	2	1	18.50	80	-0.090	2
20	GEN DYN	BGM-109	2	0.943	1	5	2	0	18.50	80	-0.090	2
21	GRUMMAN	F-9F/H	1	1.033	5	-	-	1	1.00	51	0.238	1
22	GRUMMAN	A-6A	8	0.829	1	1	-	0	1.38	61	0.017	1
23	GRUMMAN	A-6E	9	0.937	1	1	2	1	15.89	70	0.021	1
24	GRUMMAN	F-14A	11	0.99	1	1	2	0	18.00	71	0.005	1
25	LOCKHEED	P-3C	14	0.972	1	5	3	1	14.93	68	-0.013	1
26	LOCKHEED	S-3A	4	0.846	1	5	3	0	16.00	72	0.005	1
27	LTV	F-8D/C	5	0.882	-	3	3	1	0.20	58	0.027	1
28	LTV	A-7A/B	2	0.852	-	-	3	0	2.00	65	0.037	1
29	LTV	A-7E	12	1.000	5	5	3	1	12.75	67	-0.002	1
30	LTV	A-7D	7	0.950	5	5	3	1	9.86	68	-0.022	1
31	McDON D	F-101ABC	5	0.802	5	-	3	0	1.40	54	-0.009	1
32	McDON D	A-4B	2	0.834	5	-	3	1	3.00	55	0.059	1
33	McDON D	A-4C	5	0.894	3	-	3	1	0.40	57	-0.013	1
34	McDON D	A-4A/B	7	0.834	3	1	3	0	0.57	59	0.030	1
35	McDON D	A-4E	3	0.894	2	1	3	1	0.00	61	0.044	1
36	McDON D	F-4D	2	0.834	1	5	3	1	2.00	64	0.051	1
37	McDON D	F-15A	6	0.892	1	3	3	0	21.17	73	0.024	1
38	McDON D	FA-18A	3	0.886	1	3	3	0	19.67	79	-0.067	1
39	MOTOROLA	AIM-9C	6	0.961	4	3	3	1	0.83	61	0.038	2
40	NORTHRUP	F-89D	3	0.885	-	1	5	1	0.67	51	0.064	1
41	RAYTHEON	AIM-7E	1	0.949	2	-	4	1	0.00	61	0.088	2
42	RAYTHEON	AIM-7F	12	0.773	1	5	4	1	14.33	68	-0.000	2
43	RAYTHEON	AIM-7M	2	0.880	1	5	5	1	18.50	80	-0.090	2
44	REPUBLIC	F-84F	2	0.725	-	-	3	0	1.00	51	0.171	1
45	REPUBLIC	F-105B/D	5	0.759	-	-	3	0	0.40	57	-0.013	1

ID = Observation No.
INFL = Inflation
CNAME = Company Name
PNAME = Program Name
PLNGTH= Program Length
SLOPE = Learning Slope
DPR = Depreciation

ITC = Investment Tax Cedit
INV = Inventory
FOP = Follow-on Code
TTRND = Time Trend Code
UTIL = Capacity Utilization
PMCODE = Plane/Missile Code

E. SUMMARY

This chapter has addressed sample selection, data collection, and measurement of the variables that are used in the statistical tests. In the next chapter the statistical models used, tests of the models, and analysis of the results will be discussed.

V. STATISTICAL TESTS AND ANALYSIS

This chapter addresses the statistical tests of the thesis sample, including an analysis of the results. The hypothesis of the study is cost reduction rates for DoD aerospace programs may be impacted by the accounting method utilized. More specifically, it is expected that programs using liberal cost accounting methods will tend to show steeper cost reduction rates, while conservative methods tend to exhibit flatter rates. An explanation and justification for the statistical tests will be discused including testing procedures used and an analysis of results. To test the hypothesis, correlation and regression tests were performed. Learning curve slope, the dependent variable, is used to represent the cost reduction rate. Accounting method choices were the predictor variables, while economic and program characteristics were the control variables. Liberal to conservative classification for accounting variables were coded by assigning values from one (1), to five (5), respectfully.

Recall that a learning slope of less than one (1) represented a positive cost reduction rate, one (1) represented no learning, and a slope greater than one indicated negative learning. Therefore, lower learning slopes represent fastest cost reduction rates. It was

expected that liberal accounting methods like accelerated depreciation and LIFO inventory method (coded 1), would be associated with steeper cost reduction curves. Conservative accounting methods, like straight-line depreciation and FIFO inventory method, were expected to be associated with flatter cost reduction curves. This implies an expected positive correlation of learning slope with accounting variables.

A. THE STATISTICAL TESTS DEFINED

The statistical tests, executed for this study, included various combinations and subsets of the variables. Two methods, correlation and regression, were used to test the hypothesis. Both Pearson and Spearman correlations were run, as were two major sets of regressions. One regression set explored slope as a function of the accounting variables. The other is a function of both accounting and control variables.

Correlation is a measure of the strength of the linear relationship between two variables. Correlation between two variables, say variables X and Y, can be negative (Y decreases with increasing X), positive (Y increases with increasing X), or no correlation (no association between X and Y). An example of positive correlation is the association between human height and weight (as height increases so does weight). There are a number of correlation tests available. Pearson and Spearman correlation methods were used in this study.

1. Pearson and Spearman Correlations

Pearson correlations, also called product-moment correlations are most commonly used and understood. These correlations require continuous measures such that identical intervals between variable values are treated as equal, (i.e. the difference between 12 and 16 pounds is the same as the difference between 11 and 15 pounds). Many of the variables used in this study, however, are not continuous, but rather discrete.

It can be shown that the predictor variables used in the thesis study are not continuous. The development of the actual variables, used in the study, was explained in the last chapter, and the numerical values listed in table 4.2. For example the depreciation variable, used in the study, was determined by assigning the code (1) to any accelerated depreciation method and code (5) for straight-line. It is known, however, that there is more than one method of accelerated depreciation, each resulting in different cost flows. With the knowledge that the cost flows are slightly different for different accelerated depreciation methods, the assignment of code (5) is not exact, but assumes the accelerated depreciation cost flows are close enough to be valued identically. Analogously, when a firm's annual report discloses that both accelerated and straight line depreciation are used, code (3) is assigned, with the assumption that there is an even split between the two

depreciation methods. The split, however, may be 60-40 for one program and 55-45 for another. It becomes clear that an assumption of continuous measures for depreciation is invalid. (i.e. the difference between code (5) and code (3) is not the same from program to program). Spearman correlation tests, which do not assume continuous measures, but only rank ordering, are probably a preferable correlation test for this study.

The same arguments for using the Spearman correlation method, advanced in the above paragraph, also holds for inventory. When a firm uses a combination of FIFO and LIFO, it is assumed that the split is even, and a code of three (3) is assigned. As explained above, the split may not be even, but more accurate measures are not available without knowing the exact division of inventory methods.

Pairwise Pearson and Spearman correlations were generated between slope and the three accounting variables. These correlations were computed for the sample of all programs and for four separate subsamples: (1) all programs, (2) original programs (FOP = 0), (3) follow-on programs (FOP = 1), (4) planes only, or (5) missiles only. Correlations were either positive or negative and are noted with and asterisk if significant at the .10 level in Table 5.1. on page 52.

Findings from the correlation tests are only suggestive of the slope/accounting method relationships, but

TABLE 5.1

CORRELATIONS OF SLOPE WITH ACCOUNTING VARIABLES

	SUBSAMPLE				
CORRELATION	ALL	FOP = 1	FOP = 0	PLANES	MISSILES
PEARSON CORR					
INV	-.26	-.38*	-.58*	-.20	-.49
DEPR	-.18	-.12	-.45*	-.17	.03
ITC	.20	.34	-.14	.38	.01
SPEARMAN CORR					
INV	-.37*	-.41*	-.62*	-.35*	-.48
DEPR	.12	-.13	-.34	-.13	.10
ITC	.19	.35	-.13	.39	.01

* Signifies significant at < .10

indicate an apparent inverse association between inventory method choice and learning slopes, contrary to the hypothesis.

2. Regressions

The regression tests performed on the data are descriptive in nature. One of the purposes of the regression tests is to develop and analyze a statistical model that can be used to test how the values of a dependent variable depend on the values of a number of independent variables. By including multiple independent variables in a regression model the relationship between the dependent variable and

each independent variable is tested while, in effect, holding the values of the other independent variables constant. For the regression tests run in this study the dependent variable is slope, and it represents cost reduction rate. Regression of the dependent variable against multiple predictor variables, with and without controls, is designed to test the association between the independent and dependent variables.

B. THE ACTUAL STATISTICAL TESTS

The first battery of statistical tests examined learning slope as a function of accounting variables for the entire sample of programs, and for various subsets of the sample. The second battery of tests repeated the initial tests, but additionally included control variables in the regressions.

The first statistical tests modeled slope as a function of three accounting variables. The first test was conducted on the entire sample. Subsequent tests sub-divided the data by distinguishing between follow-on (FOP) and non follow-on programs, and between planes and missiles. The second set of tests added control variables to the accounting variables in the regressions. The second set of models were subdivided like the first; the entire sample, then FOP and plane/missile attributes of the programs were used to create separate subsamples.

1. Set One (1); Slope as a Function of Accounting Variables

In this set of statistical tests, the impact of only the accounting variables on cost reduction rate is investigated. In each of the five models, slope is used as the dependent variable, and the three accounting variables (depreciation, inventory, and investment tax credit) as the predictors. The first model tests all programs in the data sample, the second is limited to original programs, the third to follow-on programs, the fourth is planes only, and the fifth only missiles.

The basic hypothesis is that accounting methods impact cost reduction rate. The first model tests if cost reduction can be explained by accounting methods alone in the full sample. Subsequent models test the same relationships in subsets based on program differences.

2. Set Two (2); Slope as a Function of Both Accounting and Control Variables

For this set of statistical tests, the impact of economic and program characteristic variables are controlled for in the models. The tests are conducted on the same subsets as those in Set One. Each of the five subsets employ slope as the dependent variable and the same three accounting variables as predictors. The control variables are added to the regressions so that their impact on the model can be extracted.

C. ANALYSIS OF THE STATISTICAL TESTS

In the regression models coefficients between the accounting variables and slope that were significance at the t < .10 level were considered statistically significant. Positively signed coefficients were expected, since codes were assigned to the accounting variables such that positive associations were expected if the hypothesis held. The general results, in all the models, was that inventory was negatively associated with slopes, while ITC and depreciation showed no significant association with slope. For the most part the results were at odds with the hypothesis. Inventory was the only variable that was consistently significant at a .10 level, and the association was negative, which was not expected. Specific results are discussed below.

1. Set One (1); Slope as a Function of Accounting Variables Only

Five separate subsets of the sample were tested. Table 5.2, on page 56, summarizes the results. For each subset, except for airplane and missile subsamples, inventory was negatively associated with slope at or below a < .054 significance level. For the airplane and missile subsets there was no significant association between slope and inventory. As expected ITC was not strongly associated with slope in all cases, but depreciation also showed little association with slope. Recall that positive coefficients for inventory, depreciation, and ITC were predicted. ITC was the only variable that behaved as expected.

TABLE 5.2

REGRESSIONS OF SLOPE ON ACCOUNTING VARIABLES

	SUBSAMPLE				
	ALL	FOP = 1	FOP = 0	PLANES	MISSILES
#OBSERVATIONS	23	13	9	14	8
INTERCEPT	1.042*	1.1252*	1.1272*	1.0551*	1.1922*
COEFFICIENTS					
INV	-.0625*	-.0905*	-.1013*	-.0696	-.0685
DEPR	.0028	-.0054	.0248	.0080	-.0064
ITC	.0203	.0325	.0035	.0156	6.7599
R SQUARED	.21	.39	.57	.19	.25
ADJUSTED R^2	.09	.21	.36	-.03	.00

* Signifies coefficient significant at < .10

2. Set Two (2); Slope as a Function of Both Accounting and Control Variables

When control variables were added to the accounting variables the results were not improved. Table 5.3, on page 57, summarizes the results of the statistical tests. Instead of stronger associations, the coefficients of the accounting variables were less likely to be statistically significant.

The investment tax credit (ITC) was not significantly associated with slope in any of the five models. In three of five models, inventory and depreciation were not associated with slope at a statistically significant level. Only for the full sample of programs and the subset that included

TABLE 5.3

REGRESSIONS OF SLOPE ON ACCOUNTING AND CONTROL VARIABLES

	SUBSAMPLE				
	ALL	FOP = 1	FOP = 0	PLANES	MISSILES
#OBSERVATIONS	23	13	9	14	8
INTERCEPT	.8605	.2157	-.9562	-.6101	-.8193
COEFFICIENTS					
INV	-.0681*	-.0710	-.0788*	-.0317	-.0721
DEPR	.0150	.0246	.0399*	.0094	-.0905
ITC	.0095	.0190	.0016	.0068	-4.5822
PLENGTH	-.0024	-.0066	.0163*	.0144	-.0267
INFL	.0049	.0067	-.0130	-.0108	-.0175
TIMETRND	.0016	.0117	.0297	.0232	.0360
FOP	.0983*	-----	--------	.0452	.1272
UTIL	.3050	1.6932	1.6637	.9855	5.4735
R SQUARED	.53	.61	.97	.45	.97
ADJUSTED R^2	.28	.16	.87	-.29	.75

* Signifies coefficient significant at t < .10

original (FOP = 0) programs, were the results significant. For the full sample inventory was negatively associated and depreciation positively at levels of .095. When the sample was reduced to include only new programs (FOP = 0), inventory was again negative and depreciation positive, but at more significant levels (t < .057).

Other combinations of accounting, and accounting plus controls were tried. None of these other combinations were able to explain the relationship between slope and accounting variables in greater measure than those summarized in this chapter.

D. SUMMARY

In this chapter, explanations of and justifications for the statistical tests were explained. The actual statistical testing procedures and analysis of results were also addressed. In general it was determined that inventory was negatively associated, while depreciation and investment tax credit variables exhibited no association with the dependent variable slope.

In the concluding chapter actual results are compared to the hypothesis. Specifically, the question: "Do accounting method choices impact cost reduction rates for DoD aerospace programs?" will be answered.

VI. CONCLUSION

The purpose of this study has been to investigate the relationship between accounting methods and cost reduction rates exhibited in DoD aerospace weapons system programs. In this chapter the overall conclusions are summarized, and the hypothesis is analyzed and appraised for soundness. Finally, direction for possible future research is suggested.

A. SUMMARY OF THESIS STUDY

This study explored the role of three accounting methods (depreciation, inventory and investment tax credit) in explaining cost reduction rates. Accounting data was collected from a sample of DoD aerospace programs. Data representative of the economic climate and of program characteristics was also collected. Both accounting and control variables were used in statistical tests of the hypothesis. Any interpretation of the results should be alert to the assumptions made in the development of the variables.

The analysis was conducted on the full sample of aerospace programs and on four separate subsamples. Broadly speaking, the statistical analysis proceeded in three stages. First pairwise correlations between cost reduction slopes and individual accounting methods were determined. Second, to control for interactions between different accounting

methods, multi-variate regressions, using all three accounting variables to explain cost reduction slopes were computed. Third, to control for other economic and program characteristics, regressions including accounting variables and selected control variables were computed.

The results for inventory were generally consistent across most of the tests and subsamples; at least sufficiently consistent to state a general finding: Inventory method choice was statistically associated with cost reduction slopes, but in a direction contrary to that hypothesized. Depreciation and ITC were not associated with cost reduction slopes.

There are a number of reasons why the tests could have turned up unexpected results; the most obvious is that the hypothesis does not hold. There are, however, a number of reasons why the hypothesis might hold but could not be established by the study. The next section explores some possible arguments for the results.

B. INTERPRETATION OF THE RESULTS

The thesis hypothesis predicted different results than those achieved. Inventory was the only variable that consistently explained cost reduction rate, and the results were the opposite of that expected. Either the hypothesis doesn't hold or support of the hypothesis could not be determined because of study limitations.

1. The Hypothesis is not Valid

It is possible that the hypothesis does not hold. In previous studies and chapter III of this study, it was demonstrated that accounting variables can impact a program slope. However, the same studies also established that there are a large number of other variables that impact slope. Even with exhaustive testing, it would be difficult to determine the relative impact each of these variables. It is possible that variables, other than those associated with accounting methods, have relatively greater impact on slope and make choice of accounting methods less important.

If the hypothesis does not hold, there is still a need to explain the negative relationship between inventory methods and cost reduction, since a positive relationship was expected. It was expected that use of LIFO for inventory would lead to faster expensing of inventory costs and hence apparent cost reduction over program life. Instead, use of LIFO was associated with lack of cost reduction. Inflation may be causing this result. Increased inflation may simultaneously cause, (a) the use of LIFO and (b) higher program costs as the program proceeds, leading to the observed association between inventory method and cost reduction rate. This could explain the unexpected result. If this is the case then the inventory method is not causing the degree of cost reduction; instead a firm's inventory

method choice is simply a proxy for the real driving force, which is inflation.

2. The Hypothesis Holds but there are other Problems

The hypothesis may be valid, but limitations of the study itself have made it impossible to document the predicted relationships between accounting methods and cost reduction rate. Limitations might include: (1) the sample size was too small, (2) accounting and other variable measures used in the study are crude, (3) corporation financial disclosure is ambiguous, or (4) variables other than accounting have a greater effect on slope and because of the study's inability to control for them mask the impact of accounting variables. Another major limitation is that the cross-sectional analysis that was performed, in this study. Cross-sectional studies tend not to be able to account for contractor specific characteristics.

The thesis sample size may have been too small. Indeed, more than one third additional programs were in the original sample, but sufficient data for these programs could not be obtained for the study. A larger sample size is always desirable since the outlier effect is minimized.

Another limitation of the study were the variable measures. All the measures developed for the accounting variables were, at best, crude. As explained earlier, the data for accounting measures is discrete, rather than

continuous, so measures developed for the variables is judgmental.

The ambiguity of financial disclosure for the firms in the study was also a problem. In a number of cases accounting methods were not disclosed and, where possible, judgments as to method used were made. The accuracy of these judgments is limited by the data available. Also many of the corporations are multi-faceted with aerospace only one of a number of subsidiary interests. When the aerospace industry is one of a number of subsidiaries that make a conglomerate, the accounting methods used by that division are rarely distinguished, in the financial statements, from those of the overall firm. Though accounting methods may vary from subsidiary to subsidiary, the accounting methods used by the entire firm were used for this study.

Many other variables can effect slope, and the reason the hypothesis was not supported may be that these other influences masked the study's ability to observe the hypothesized relationships. If more variables and a larger model were developed the results may have been different. Alternatively if those variables that tend to influence the model in similar ways were removed, so that only one variable represented one influence, the results may have differed.

This study employed cross sectional analysis on the data, which tends not to be able to account for contractor specific characteristics. A time series study of individual

contractors was attempted in this study, but there wasn't enough data points to make it meaningful. If data could be collected directly from contractors the confidence in the data would be significantly greater. Greater data confidence would allow a smaller sample to be used, and a time series analysis, separating programs by contractor, could be performed.

There are a number of reasons why the hypothesis might hold, but was not supported by the study. The possible reasons for the lack of hypothesis support cited in this section have concentrated on sample size, and data confidence Better data and more accurate data measures may generate an improved study.

C. RECOMMENDATION FOR POSSIBLE FUTURE RESEARCH

In attempting to answer questions similar to those asked in this study, data problems are paramount. To acquire reliable data, contractors would have to provide actual accounting data for each program studied. With better data, the same type of study as the one completed in this thesis or a time series study could be undertaken and conceivably yield more significant results.

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